

CLAIMS

1. An illumination optical device having a light source for supplying pulse laser light, which illuminates an irradiated plane with light from the light source, comprising:

a diffractive optical element arranged in an optical path between the light source and the irradiated plane, through which a light beam having an energy density of $1 \text{ mJ/cm}^2/\text{pulse}$ or more passes, wherein

an optical material forming the diffractive optical element includes an oxide crystal material.

2. The illumination optical device according to claim 1, wherein the diffractive optical element is arranged in an optical path between the light source and the irradiated plane, through which a light beam having an energy density of $10 \text{ mJ/cm}^2/\text{pulse}$ or more passes.

3. An illumination optical device having a light source for supplying pulse laser light, which illuminates an irradiated plane with light from the light source, comprising:

a refractive optical element arranged in an optical path between the light source and the irradiated plane, through which a light beam having an energy density of $1 \text{ mJ/cm}^2/\text{pulse}$ or more passes,

wherein

the refractive optical element has a refraction pattern arranged one-dimensionally or two-dimensionally, and wherein

5 an optical material forming the refractive optical element includes an oxide crystal material.

4. The illumination optical device according to claim 3, wherein the refractive optical element is arranged in an optical path between the light source and the irradiated plane, through which a light beam having an energy density of 10 mJ/cm²/pulse or more passes.

10

5. The illumination optical device according to any of claims 1 to 4, wherein the oxide crystal material is one of quartz crystal (SiO₂), barium titanate (BaTiO₃), titanium trioxide (TiO₃), magnesium oxide (MgO), and sapphire (Al₂O₃).

15

6. The illumination optical device according to any of claims 1 to 5, wherein the diffractive optical element or the refractive optical element transforms an incident light beam into a light beam having a given light intensity distribution.

20

7. The illumination optical device according to any of claims 1 to 6, further comprising:

25 an optical integrator for forming a secondary light source in a given shape on an illumination pupil

plane based on a light beam through the diffractive optical element or the refractive optical element.

8. The illumination optical device according to any of claims 1 to 7, wherein an optic axis of the oxide crystal material is set approximately parallel to an optical axis of the illumination optical device.

9. The illumination optical device according to claim 8, wherein

the oxide crystal material comprises a plurality of optic axes, and wherein

one of the plurality of optic axes is set approximately parallel to the optical axis of the illumination optical device.

10. The illumination optical device according to any of claims 1 to 9, wherein the diffractive optical element or the refractive optical element has a surface shape formed by dry etching.

11. A photolithography machine, comprising:

the illumination optical device according to any of claims 1 to 10; and

a projection optical system for projecting and exposing a pattern of a mask arranged on the irradiated plane on a photosensitive substrate.

12. An exposure method, wherein

a mask is illuminated through the illumination optical device according to any of claims 1 to 10, and

wherein

an image of a pattern formed on the illuminated mask is projected and exposed on a photosensitive substrate.